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AUTHOR Van Deventer, William C.; Duyser, Lucille
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ABSTRACT

The tests included in this document are teacher-constructed. They are based on questions asked by students in connection with and following completion of laboratory experiences directed toward the understanding of specific "Ideas". The "Ideas" were taught, the laboratory experiences were completed, the tests were constructed, and the test keys were prepared in accordance with the practices recommended in "Suggested Procedures for Teachers Using the Idea-Centered Laboratory Science Program." The tests described are intended to serve as samples and it is recommended that they should not be used outside the setting for which they were constructed. The samples given in this paper are models which the teacher can follow in constructing his own tests. These tests are designed to measure the quality and extent of students' thinking in relation to specific "Ideas". (BR)

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Sample Tests

The tests included in this section are teacher-constructed tests. They are based on questions asked by students in connection with and following completion of laboratory experiences directed toward the understanding of specific Ideas. The Ideas were taught, the laboratory experiences were carried out, the tests were constructed, and the test keys were prepared in accordance with the practices recommended in Suggested Procedure for Teachers Using the I-CLS Program (See the following pages).

These tests are samples only. They should not be used outside the setting for which they were constructed. Teachers should construct their own tests of this type, following the practices recommended in the Suggested Procedure, using these tests as models.

These tests are designed to measure only the quality and extent of students' thinking in relation to specific Ideas. Teachers should feel free to use also any other tests or other types of evaluation to measure factual recall, problem solving ability, interest in science, or any other desired outcomes.

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Suggested Procedure for Teachers Using the I-CLS Program

1. You will have best results, at least to start, if you approach the material and teach it one Idea at a time. Finish one Idea, then go to another, and then another. At a convenient and desirable later point, you may wish to tie several Ideas together.

2. Make sure that you yourself understand the Idea, as it is expressed in the Idea-Bridge. This is the writers' statement of the Idea, as it is used in the materials, and tells what the writers mean by it.

3. Communicate the Idea to your students. Let them read the Idea-Bridge for themselves, but if you feel that it is not stated in language that they can understand, "translate" it for them. This translation job is your responsibility. Furthermore, in doing this, you will become better acquainted with the Idea yourself. Remember that students with different levels of ability may require different "translations." The Idea can be translated, however, in some intellectually honest form for students at any ability level.

4. Spend up to a whole period discussing the Idea with the students. Help them relate it to their own past experiences. Give them an opportunity to ask questions freely concerning the Idea, and do not worry as to whether or not the questions are answerable. Don't be afraid to say, "I don't know."

5. Write the Idea on the chalkboard in abbreviated form. You will need to "boil down" the statement in the Idea-Bridge to do this. Leave it on the board, if possible, while you are working with the laboratory experiences directed toward the Idea. If you must remove it, write it on the board again frequently.

6. Work out the laboratory experiences which look toward the Idea. As you do so, direct the students' attention to the Idea by asking them leading, open-ended questions of your own devising related to it. These will supplement the questions included in the laboratory directions. As far as possible, the questions should be "why" or "how-why" questions, rather than simple "how" or "what" questions.

7. Let the laboratory experiences be as open-ended as possible. Allow the students to arrive at wrong answers sometimes, while seeking for right ones. Give them "the right to be wrong." It is always possible to correct a wrong answer, but it is very difficult to rectify a "cookbook" method.

8. Spend up to a whole period again with the students after the laboratory experiences are completed, going over the Idea with them by way of summary, and giving them a further opportunity to ask questions about it, this time with emphasis on the laboratory experiences directed toward it.

The way in which students' questions are used to evaluate their thinking includes the following steps:

1. After the final summary and review session with the class (Step 8 above), ask the students to write down as many questions as they can which are related to the Idea that has been studied. Be sure that a brief, clear statement of the Idea is on the chalkboard while they are doing this.

2. From the students' written questions, prepare two lists:

   a. Those questions that in your judgment apply to the Idea.

   b. Those questions that in your judgment do not apply to the Idea.

   c. Discard any questions that do not clearly belong in one list or the other.

3. Select 15-30 questions (the same number) from each list. Choose what you believe to be the "best" questions from each list. The questions should all be valid questions, but they do not need to be answerable.

4. Scramble the 30-60 questions that you have selected into a two-choice test. Ask the students to distinguish between the questions that do apply to the Idea, and those that do not apply. They do not need to answer the questions. Tell them that half of the questions do apply, and half do not apply. Place at the beginning of the test the brief statement of the Idea that you have used before, so that they can refer to it while they are marking the test.

Several methods have been tried experimentally for keying a test of this type. A teacher or group of teachers may simply set up a key on the basis of individual or collective judgment. The original classification of the questions used in preparation of the test may be followed as a key, or it may be modified on the basis of the judgment of other teachers.

Another method is to use an item analysis of collective student judgment after giving the test as a basis for making a key, modifying this as necessary on the basis of individual or collective teacher judgment. One teacher allows the students to discuss the test items, a few at a time, in small committees before marking the test, then follows with an item analysis of the collective judgment of the entire class, and finally makes modifications on the basis of teacher judgment. In general, it is probable that the broader the basis for judgment in making the key, the better the key.

Test to Determine Your Understanding of the Idea of Observing Through the Use of All Five Senses (A.1.)*

Idea:

You are always collecting observations. Your brain is constantly receiving information from the world outside. The process of observation is the receiving of information by the brain. The brain receives all of its information from the five senses. Without these five gateways to the brain there would be no such thing as observation. Without observations your brain would have no knowledge.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.
2. Then read through the entire list of questions carefully without marking any of them.
3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.
4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.
5. Do this again and again until you have marked "+" in front of a total of twenty questions.
6. Then go back again and mark "o" in front of the twenty questions that are left.
7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o".

o 1. What pieces of equipment do you know right off?
\+ 2. Did we really see the lines move in the optical illusion?
\+ 3. If a bottle of vinegar is placed in the middle of the room what part of you would tell you it was vinegar?
o 4. What are the five senses?
\+ 5. When you eat your food which of your abilities helps you to know which you like and which you dislike?
\+ 6. If you saw a wanted poster of one of the top ten wanted men, do you think you would recognize the man if you saw him?
o 7. Does thanitol have an odor?
o 8. What does a thermometer do?
o 9. Can anyone have an illusion?

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*Test prepared by Mr. Steven Wheeler, Chairman of the Science Department, Lee Senior Elementary School, Woodland, California.

o 10. How do scales help us?
+ 11. What ability aids you in telling that something is rough?
+ 12. If you were blindfolded and someone gave you a piece of apple, then a piece of onion would you be able to taste the difference?
o 13. What is an optical illusion?
o 14. What is a phenomenon?
+ 15. Can you improve your skills of seeing, hearing, tasting and smelling by practice?
+ 16. Why is it hard to hear sound from certain places without seeing where it originates?
+ 17. Why can't you hear your voice very well in a room full of noise?
+ 18. Can your eyes always catch all the details of things?
o 19. Is it true that if a whistle was blown on one side of the room it will have the same loudness on the other side?
o 20. Are there five or six senses?
+ 21. If you are told that a certain odor is coming from a bottle, can your nose really give you dependable information about the type of odor?
o 22. What does the term irrelevant mean?
o 23. What happens to the light from an object when it is refracted through a lens?
+ 24. Will a person's senses always be accurate in "telling it like it is?"
o 25. If you were struck blind what would happen to your other senses?
o 26. What is observation?
o 27. How many senses are present in the mouth?
o 28. How does today's modern music affect us?
+ 29. Which of your abilities tells you the difference between an earthquake and a flood?
+ 30. How many other things would you have smelled in the classroom if you could smell as well as a dog?
o 31. Would common sense be the sixth sense?
o 32. What does a scientist do before he makes up his mind?
o 33. Can you always depend upon your five senses?
o 34. What is the relationship between common sense and observation?
+ 35. Why do our eyes see yellow when we look at a banana?
+ 36. Why does water feel wet?
+ 37. What senses would a blind man use in describing a light fixture?
+ 38. What color do we see the classroom celing to be?
+ 39. Can your hands feel the smoothness of the table tops?
+ 40. What makes your eyes see things in color?

Test to Determine Your Understanding of the Ideas of Observing and Asking Questions (A.1. and A.2.)*

Ideas:

Scientists observe and ask questions. Observation is more than looking. It involves concentration, thought, and attention to detail, as well as using all of the senses. Scientists, however, realize the limits of their senses. They know their senses are not always trustworthy. They use instruments to aid and extend their senses. Observation leads to asking questions and discovering problems. One definition of science is "asking nature simple questions, one at a time, and writing down the answers."

Instructions:

1. Read the Ideas through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Ideas.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of twenty questions.

6. Then go back again and mark "o" in front of the twenty questions that are left.

7. Think through and study each question carefully in relation to the Ideas before you mark it either "+" or "o".

\+ 1. Does seeing a problem over and over help because you see it over and over?
o 2. What is thanitol used for?
\+ 3. Is it possible to sharpen your senses through practice?
\+ 4. Are your ears as dependable as your eyes?
o 5. What are the five senses?
o 6. Why do we have to have penicillin shots?
o 7. What is perfect pitch?
\+ 8. Is there a way to measure common sense?
\+ 9. Are there certain steps in observing?
o 10. What is chlorophyll?

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*Test prepared by Mr. Ronald C. Laugen, Mannheim American High School, Mannheim, Germany.

o 11. What does recurrence mean?
+ 12. Why is sharpening our observational skills important?
+ 13. Do you always have questions, even after you have studied something?
o 14. Why did we use a newspaper picture of a man?
o 15. What does a microscope do?
o 16. What are deciduous trees?
+ 17. Why do people detect taste differently?
o 18. Why do some leaves have bugs on them?
o 19. Do all plants lean toward the sun?
+ 20. Can all of our senses be fooled by suggestion?
+ 21. Are there answers to all questions when we observe something?
o 22. Why did the peppers appear wrinkled?
+ 23. Can illusions ever help us solve problems?
o 24. How do you know when a description is a composite?
+ 25. Why do the other senses get stronger when one is gone?
o 26. What is a laboratory?
+ 27. Do you ever observe just by looking?
+ 28. How does a scientist find a discrepancy?
+ 29. Do most people see optical illusions?
+ 30. Why do some people smell things you don't?
o 31. What is the difference between relevant and irrelevant?
o 32. Why don't the needles of a pine tree fall off?
o 33. Why do the plants have moss on the soil?
o 34. What does science tell you?
+ 35. What causes us to be fooled by our ears?
+ 36. What is the reason for observing things?
+ 37. Are there certain ways to ask questions?
+ 38. Can plants be fooled by weather?
o 39. How come the newspaper has dots on it?
o 40. What are leaves made of?

Test to Determine Your Understanding of the Idea of Asking Questions*

Idea: When we observe we see much that we do not understand. We see events that repeat themselves (recurrences), and things that do not behave as we had thought they would (discrepancies). In all of our experiences our observations of things and events lead us to ask questions about these observations.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of twenty questions.

6. Then go back again and mark "o" in front of the twenty questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

\+ 1. Why do leaves turn different colors in the fall?
\+ 2. Why do plants with enough light grow straight, while plants with not enough light grow outward?
o 3. Do all leaves die?
\+ 4. Why did the leaf turn red when we put it into a sugar solution?
o 5. What are trees made of?
o 6. How do you know it is fall?
\+ 7. Why do scientists sometimes go into the field to observe animals and plants?
\+ 8. Why is most tree bark brown rather than green?
o 9. Is recurrence due to weather change?
\+ 10. Why do the leaf stems (petioles) form a corky layer before breaking off?
o 11. Do trees help scientists in their work?
o 12. Does a scientist work on rocks?
\+ 13. Why do some people make their yards look awful with junk?
o 14. Do trees need sunshine?
o 15. How can you tell if leaves are healthy?
\+ 16. Why is the leaf of one of our plants dying?
o 17. What are deciduous trees?
\+ 18. Why do some leaves die sooner than others?

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*Test prepared by Mr. Steven Wheeler, Chairman of the Science Department, Lee Senior Elementary School, Woodland, California.

+ 19. Which leaves have the most chlorophyll---green, yellow, or purplish red?
o 20. Do plants need sunshine and water?
o 21. Do plants help people?
+ 22. Do leaves always change color?
o 23. What is a variable?
+ 24. What does cold have to do with color change in leaves?
+ 25. How fast does a plant leaf react to light?
o 26. What do glaciers have to do with the flood theory?
+ 27. Why do people change their behavior in so many ways?
o 28. Are theories helpful to scientists?
+ 29. Why do animals react differently in cages than they do in their natural life space?
o 30. How does a scientist create a problem?
o 31. What does a scientist do when he dissects?
+ 32. How could observed discrepancies lead scientists to make closer examinations?
o 33. How does a scientist know what experiments to do?
+ 34. Why do the veins stick out on the undersides of leaves but not on the topsides?
+ 35. Why do the leaves on the north side of the tree change color and fall first?
o 36. Can a discrepancy be found anywhere?
+ 37. If two seeds are alike and are planted at the same depth, why does one grow taller than the other?
o 38. What are leaves made of?
+ 39. We covered a branch of a tree with a black bag---Why did the leaves on it turn yellow in a few days?
o 40. Is weather a variable?

Test to Determine Your Understanding of the Idea of Hypothesis Forming and Testing (A.3.)*

Idea:

Scientists have a definite method of solving problems. It is outlined in the Cycle of Proof. When a scientist is faced with a problem he collects all the facts (data) he can and then arrives at a tentative explanation called a hypothesis. He arrives at this hypothesis by inductive thinking. This means starting with facts and trying to find an explanation for them. The hypothesis is tested by seeing if it explains additional facts. Trying it out in this way is called deductive procedure. Even though all available data agree with the hypothesis it still may be changed because of new data or greater understanding.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of fifteen questions.

6. Then go back again and mark "o" in front of the fifteen questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

\+ 1. Were your guesses on length of time related to a hypothesis?
o 2. Does the cycle of proof help you in guessing which way a coin will fall when you flip it?
o 3. Do the sun, moon and stars undergo a change?
\+ 4. Is a generalization a part of a tentative explanation?
\+ 5. Is there a relationship between problem solving in everyday life and scientific problem solving?
\+ 6. What is an example of inductive thinking?
o 7. Why did it take so many BB's to cause the water to overflow?
o 8. What is meant by the natural world?
o 9. What is the Cycle of Proof?
o 10. What is a hypothesis?
\+ 11. When a hypothesis is strengthened or proven what is it then called?
\+ 12. Do all the scientist's data have to agree with his tentative explanation?

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*Test prepared by Mr. Ted Wernert, Iriquois Middle School, West Irondequoit Central School District, Rochester, New York.

+ 13. Why do tails come up most often when flipping pennies?
o 14. Why are there natural laws?
o 15. What is a phenomenon?
+ 16. Does the world have a consistent pattern?
+ 17. Does a scientist have to use experimentation in solving all problems?
+ 18. How can relationships or patterns be tested?
o 19. What is an example of inductive thinking?
o 20. What does a "dependable world" mean?
o 21. What is the scientist's final goal in the world?
+ 22. Is there any difference between "apparently true" and "possibly true?"
o 23. Are deductive and inductive reasoning both a part of the cycle of proof?
+ 24. Why must the scientist return to his starting point if his data don't agree?
+ 25. When a detective talks about "deduction," does he mean the same thing that a scientist does when he uses "deductive?"
o 26. What do we mean by a pattern in nature?
+ 27. Do warping factors have any affect on p nny flipping?
o 28. Do people tend to be under or over when guessing time?
+ 29. Would a person's age have anything to do with guessing?
o 30. Does the inductive process have anything to do with your tentative explanation?

Test to Determine Your Understanding of the Idea of Objectivity and Tentativeness (A.4.)*

Idea:

When a scientist observes a set of phenomena, or series of events that he does not understand, he looks for an explanation that seems to "make sense." He sets up this tentative explanation as a hypothesis. He studies the problem objectively. (He keeps his feelings and prejudices out of consideration, and tries to look at the problem as if it were someone else's.) Even when he has found a workable solution, he continues to maintain an objective attitude. Any conclusion that he reaches is tentative. (He does not allow himself to become "set" in his thinking, and he is willing to change or discard his conclusion if new contradictory data are found.)

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of twenty questions.

6. Then go back again and mark "o" in front of the twenty questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

\+ 1. Should you believe everything you read in the newspaper?
o 2. What is a discrepancy?
\+ 3. Are all flying saucers natural phenomena?
\+ 4. Do some people really have E.S.P.?
\+ 5. Are people telling the truth when they say they see U.F.O.'s?
o 6. What is meant by the term "warping factor?"
o 7. Does telepathy mean sending thoughts from one mind to another?
\+ 8. Do you think everyone has a certain amount of E.S.P.?
o 9. How important is concentration in guessing cards?
o 10. Are most science newspaper articles interesting?
\+ 11. Is it possible for some science fiction stories to "come true?"
o 12. What is E.S.P.?
o 13. What might be a warping factor in the card guessing experience?

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*Test prepared by Mr. Ted Wernert, Iriquois Middle School, West Irondequoit Central School District, Rochester, New York.

+ 14. If a person has better than chance results in guessing cards, would he have better than chance results with other things?
+ 15. Does the number of things from which you have to choose affect your chance expectancy?
o 16. Why do some people have precognition?
o 17. Is chance expectancy useful at all in a science lab?
o 18. Does whether you deal off the top or bottom of the deck influence chance expectancy?
+ 19. Would a "card shark" be more likely to have E.S.P.?
+ 20. Do you really need playing cards or dice to prove the existence of E.S.P.?
+ 21. Can you believe the science articles you read in the newspapers?
o 22. What does objectivity mean?
o 23. What is a complete Cycle of Proof?
+ 24. When a science fiction story is based on real science, is it a kind of prediction?
o 25. Are there warping factors in everything?
o 26. What is meant by a "dependable world?"
+ 27. Could there really be life on some other planets?
o 28. What is a "science oriented" world?
+ 29. Should you always be objective about something that is tentative?
o 30. Why do most U.F.O. sightings take place at night?
o 31. Does nature have anything to do with chance expectations?
+ 32. Are your grades in school affected by concentrating or guessing?
+ 33. How would you go about finding out if a newspaper article is telling the truth?
+ 34. Would an objective person always have a better answer to a problem than a person who is not objective?
+ 35. Can you really find out if you have E.S.P. by guessing cards?
+ 36. If U.F.O.'s are real, are they dangerous?
o 37. Can loaded dice change your mental waves?
o 38. What kinds of warping factors are in the cards?
+ 39. Would it be possible for U.F.O.'s to come to earth from outer space?
o 40. How do our laboratory experiences with beans, pennies, and cards relate to one another?

Test to Determine Your Understanding of the Idea of Patterns in Nature and Their Relationship to Natural Laws (A.5.)*

Idea:

Scientists observe different kinds of changes in nature, and look for patterns in the behavior of the natural world. They set up hypotheses to describe these patterns, and try to find out if the patterns are consistent. If the patterns are consistent, scientists use them to predict future behavior. Natural laws are descriptions of consistent patterns in the behavior of the natural world.

Instructions:

1. First, read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then, read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of twenty questions "+".

6. Then go back and mark "o" in front of the twenty questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

\+ 1. Do the things you do each day follow a pattern, or do they exhibit patternless change?
o 2. Are there some scientific experiments that do not involve problems?
\+ 3. Does the weather show patterned or patternless change?
o 4. How is patternless change produced?
o 5. How long will yeast cells continue to show patternless movement?
\+ 6. Do the seasons of the year make a pattern?
\+ 7. To what extent can we rely on the past to predict the future?
o 8. Does human behavior correspond to animal behavior?
o 9. How many patterns of human behavior are there?
\+ 10. In the morning do you always put on one sock before the other?
\+ 11. If we extended our observations for a longer period, would the results stay about the same?
o 12. Are there more cars going by on a one-way street?
o 13. Why do you use yeast cells and chalk dust to study patternless change?

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*Test prepared by Mr. LaMoine Motz, teacher at Hillside Junior High School, Kalamazoo, Michigan, and graduate student in Science Education, Western Michigan University and University of Michigan.

+ 14. Do most things in nature follow patterns?
+ 15. How is it possible to predict on the basis of patterns?
o 16. How does a magnet produce a pattern with iron filings?
o 17. Why are there so many cars one day and fewer the next day?
+ 18. How can you make a hypothesis in relation to patternless change?
+ 19. What would the world be like with no patterns at all?
o 20. Would you like to live in a world where nothing formed a pattern?
+ 21. Are there patterns in the way the branches of different kinds of trees spread out?
o 22. Why do people pick different times to go to work?
o 23. Is it possible to correct errors in human behavior?
+ 24. Does the search for patterns in nature lead to the discovery of problems?
+ 25. How are natural laws related to hypotheses?
o 26. Are the things you see when you mix chalk dust and water, cells or particles?
o 27. Would a magnet have any effect on yeast cells or chalk particles?
+ 28. Would the weather have any effect in changing a pattern of human behavior?
+ 29. Can you have warping factors that affect patterns?
+ 30. Is a normal curve a kind of pattern?
o 31. Why did the yeast cells move at different speeds?
+ 32. Are there patterns in simple things, like wind and rain, clouds and sunshine?
o 33. Do human cells look like yeast cells?
+ 34. Does human behavior ever appear to be patternless like Brownian movement?
o 35. What would happen if you mixed yeast cells and chalk dust?
o 36. If you used a powerful microscope, would the yeast cells and chalk dust appear to move faster?
+ 37. How can we be sure that the sun will come up every day?
o 38. Why do the yeast cells move in different directions?
+ 39. Without knowing about patterns, would it ever be possible to predict anything?
o 40. Do all kinds of cells show Brownian movement?

Test to Determine Your Understanding of the Idea of Categorizing (Classifying) Things (B.1.)*

Idea:

We can put things into groups becasue of their similarities, and then separate these groups from one another because of their differences. Larger groups can be broken up into subgroups in the same way. When we do this we can identify individuals as belonging to particular groups and subgroups. We can make a key on the basis of similarities and differences that will make it possible for anyone else to classify (categorize) individuals into groups and subgroups in the same way that we have done.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of fifteen questions.

6. Then go back again and mark "o" in front of the fifteen questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

o 1. What is a category?
o 2. What are miscellaneous objects?
+ 3. Do degrees of similarity indicate closeness of relationship?
+ 4. Could leaves of a tree and pages of a book be categorized according to similarities?
o 5. Why do we categorize?
+ 6. How do scientists discover relationships?
o 7. Does everyone categorize?
+ 8. Do all objects that are in the same group have to be exactly alike?
o 9. Is impenetrability a general property?
+ 10. What is the reason for making a key?
o 11. What is the difference between gross and subtle?
+ 12. Can similarities and differences be categorized?

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*Test prepared by Mr. Ted Wernert, Iriquois Middle School, West Irondequoit Central School District, Rochester, New York.

+ 13. Is an oak leaf like a chipmunk?
o 14. How many science fiction books were written by Jules Verne?
+ 15. Is it possible to categorize things by both similarities and differences?
+ 16. Could you categorize things if you did not know what they were?
+ 17. Why does classification make it easier to study the world?
o 18. What does discrepancy mean?
o 19. Why are most things different?
o 20. Could we categorize if all things were exactly alike?
+ 21. Is it possible to categorize a group of things that are made up of both living and non-living things.
o 22. Would special properties be more important than general properties?
o 23. Which is most important, similarities or differences?
+ 24. Are all geometric shapes similar in any way?
+ 25. Would non-living things form gradients?
o 26. What is absolute zero?
o 27. Are atoms alive?
+ 28. Is there more variation in man-made things than living things?
+ 29. What makes it possible to categorize?
o 30. How long would it take to categorize all living things?

Test to Determine Your Understanding of the Idea of Quantification (B.2.)*

Idea:

All measurement is relative, which means something is compared to something else. All units of measurement are man-made. The importance of the units of measurement we use, and the importance of the actual measurements we obtain are relative (compared) to the sizes of the things we are measuring, and the size and importance of the problems for which we need the measurements.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of fifteen questions.

6. Then go back again and mark "o" in front of the fifteen questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

\+ 1. Why do we say all measurement is relative?
o 2. What does the prefix "deci" mean?
\+ 3. Could each person make up his own system of measurement.
\+ 4. Is there a relationship between the unit of measure and precision of measurement?
o 5. What is the meaning of relationship?
o 6. What is a graduated cylinder?
\+ 7. What is the difference between absolute and relative error?
\+ 8. What is the difference between accuracy and precision?
o 9. Do scientists depend on accuracy in their work?
o 10. Could we live without accuracy?
\+ 11. Does calibrating a ruler make it more precise?
o 12. What is the metric system based on?
\+ 13. What is a standard unit of measurement?
o 14. How long is a meter?
\+ 15. What is the relationship between volume and weight in the metric system?

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*Test prepared by Mr. Ted Wernert, Iriquois Middle School, West Irondequoit Central School District, Rochester, New York.

+ 16. What kinds of distances would you measure in light years?
o 17. What is a millimeter?
+ 18. If a box was made in Europe would its measurements (units) be the same as one made in the United States?
+ 19. Can you know the weight of fifty milliliters of water without weighing it?
o 20. What is a meniscus?
+ 21. Does temperature of water have anything to do with its weight?
o 22. Do one thousand meters equal one kilometer?
+ 23. Does the size of the absolute error affect the amount of relative error?
o 24. Could we live without any form of measurement?
+ 25. Which is more precise, an inch or a centimeter?
o 26. What is the smallest unit of measurement?
o 27. What is an estimate?
+ 28. Is there an absolute error for all measurement?
o 29. What is linear measurement?
o 30. Why isn't the metric system used by the United States?

Test to Determine Your Understanding of the Idea of Normal Curves*

Idea:

Variations are a fact of nature. Many things show variation in a pattern around an average or norm. Such variations can be recorded in the form of a graph. The point on the graph where the variations "pile up" is called the mode. If the mode is the same as the norm (average), the pattern is called a normal curve ("bell curve"). In a normal curve most of the data are at or near the norm, and the rest are found with decreasing frequency on each side of it. Sometimes curves are modified as a result of the operation of warping factors. In general, the larger the sample studied, the more dependable are the results obtained.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of twenty questions.

6. Then go back again and mark "o" in front of the twenty questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

\+ 1. How many samples does it take to get a definite idea of a population?
\+ 2. If you took one bean what would be the chances of getting one that was the same as the mode?
o 3. Why do warping factors occur?
\+ 4. Do you think that odd things should be considered freaks?
o 5. Why are things in nature not alike?
\+ 6. Why is there sometimes more than one mode?
o 7. What happens if I measure the same bean twice?
o 8. What type of warping factors could be found in lima bean measuring?
\+ 9. Is there any definite size or number of objects that make up an adequate sample?
o 10. How much variation is there in lima bean sizes?
\+ 11. Is it always a normal curve when, on the graph it has points on both sides of the high point that are a few less than the high point?
o 12. Was the only purpose in measuring the beans to see how it formed a bell shaped curve?

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*Test prepared by the staff of Finneytown High School, Fontainebleau Terrace, Cincinnati, Ohio.

o 13. Do scientists sample all species?
+ 14. Would any other kind of vegetables be good to work with in this kind of experiment?
+ 15. If you measured the height of 100 people, would you get a normal curve?
+ 16. What would be the steps taken in setting up a normal distribution curve on different living species?
o 17. Why is 20 mm almost always the mode for lima beans?
o 18. Why do we have to make graphs to show our results?
+ 19. Why can different graphs of the same species have different norms?
+ 20. Is it possible to measure a hundred of something and not have any sign of a normal curve?
o 21. Are there any populations exactly alike?
+ 22. When you have a warping factor, is there a mode?
o 23. How would you go about getting an adequate sample for 10 million people?
o 24. Why is there such a big difference in size between some of the beans?
+ 25. Do you only get normal curves with plants or could you measure the length of a group of children's pencils at the end of a week?
+ 26. When you graph any human characteristic is it possible to have a perfect normal curve?
o 27. What does a lima bean consist of?
+ 28. If in 20 beans, you find the longest and shortest, is that an adequate sample?
o 29. How much variation occurs in lima bean sizes?
o 30. How does it mean to "pick by random?"
o 31. Could a computer sample all the bean lengths?
+ 32. Can there be more than one mode in a series?
+ 33. If you have a larger number of beans, will your results be much better?
+ 34. Can you sometimes tell where a mode is beginning after 4 times?
o 35. What would happen if you used all different kinds of beans?
o 36. Could the length of the bean be related to the environment?
+ 37. Why was the mode the same in my results, my class results, and five class results?
+ 38. Could something else be studied about lima beans and form a normal curve?
o 39. What happens if all of the measurements come out the same number?
o 40. Would you consider people from a million years ago freaks?

Test to Determine Your Understanding of the Idea of a Gradient*

Idea:

A gradient is a gradual but steady variation in a particular direction. A gradient may be expressed in the form of a graph. The graph, then, is a picture or two-dimensional model of the gradient. Nature is full of examples of gradients.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.
2. Then read through the entire list of questions carefully without marking any of them.
3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.
4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.
5. Do this again and again until you have marked "+" in front of a total of twenty questions.
6. Then go back again and mark "o" in front of the twenty questions that are left.
7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

\+ 1. How are normal curves related to gradients?
o 2. Is a chalk board an example of a gradient?
\+ 3. Would a road going down a mountain into a valley constitute a gradient?
o 4. Would the number of shaves you can get with a Gillette Superblade be an example of a gradient?
o 5. Is this a gradient: cold weather and high winds?
\+ 6. An airplane is getting ready to land; when it begins to lose altitute would that be a gradient?
o 7. Would the number of people in the United States in 1965 be a gradient?
o 8. What are some examples of how gradients are used?
\+ 9. Do gradients have anything to do with the growth of a child?
o 10. In the experience we did, some people said it took them longer to do the puzzle the second time than it did the first time; what is one reason why it could have happened this way?
\+ 11. Is a gradient the process by which something ascends or descends?
o 12. Do the pieces of the puzzle in this experience have to be triangular?
\+ 13. A boy got a bicycle; the first day he could ride three blocs, the next day five, and the next day ten without falling off; could this be an example of a gradient?

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*Test prepared by Mr. Richard Zubulake, Hillside Junior High School, Kalamazoo, Michigan, and graduate student in science education at Western Michigan University and the University of Michigan.

+ 14. What is an inclined plane; is it a gradient?
o 15. Does the age of a person make any difference in putting the puzzle together?
+ 16. Can gradients be used in a comparison between two things?
o 17. Did the number of parts in a puzzle make any difference in the length of time it took us to learn it?
+ 18. A pencil when it is sharpened tapers toward the tip; is this a gradient?
o 19. If Tom can put the puzzle together faster than Dick, does this mean that Tom is smarter than Dick?
+ 20. Does the yearly increase in manufacturing in the United States for the last ten years constitute a gradient?
+ 21. Can gradients be related to the weather?
o 22. Why do you have to reduce a problem to its simplest terms before trying to solve it?
+ 23. Is the growth of a tree recorded over a period of twenty-five years a gradient?
o 24. Why would it get colder going north?
o 25. If other animals had minds like we humans have, would they be able to work a puzzle faster or slower than we did?
+ 26. Could changes in the water level of the Great Lakes be expressed as a gradient?
+ 27. Would a gradient apply to your height each year from the time you are two years old until you are twelve years old?
o 28. Could anyone learn to do anything in less than three seconds?
+ 29. Is the incline of a hill a gradient?
o 30. Can a person learn in any other way than by repeating a process over and over?
o 31. How is time related to normal curves?
+ 32. If a person is learning to do something, would a record of his errors constitute a gradient?
o 33. Does this experience prove how much intelligence we have?
o 34. Will this experience affect our everyday lives in the future?
o 35. Would measuring be a form of gradient?
+ 36. The first time we worked the puzzle it was hard, but the second time it came easier; is this basically the same as when a baby starts to walk, the first time it is hard, but the second and third times it comes easier?
+ 37. Would a path going down a hill and a learning curve both mean gradient in general?
+ 38. Does the growth of a blade of grass constitute a gradient?
o 39. Why are some people more skilled than others?
+ 40. When a river flows, is it an example of a decreasing gradient?

Test to Determine Your Understanding of the Idea of Extrapolation and Interpolation*

(Based on Laboratory Experience D.3.d. Alternative Hypotheses: An Experience in Extrapolation)

Idea:

A scientist may extend a graph or picture or diagram in a way consistent with what he already knows. This is called extrapolation. He is attempting to "judge the future by the past." He may also fill in data that are needed to complete a graph or picture or diagram. This is called interpolation. Both extrapolation and interpolation are really predictions of data that may later be discovered.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of twenty questions.

6. Then go back again and mark "o" in front of the twenty questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

o 1. Why do the four bits of data form the outline of a square in our minds?
\+ 2. Why can't you draw a ∪ by extrapolation from four dots if you can draw an X ? Both have open ends.
o 3. Do other animals, such as cats and dogs, extrapolate or predict?
o 4. Why would you not be able to enlarge or shrink your dots to fit figures already made?
o 5. How does a circle differ from an ellipse?
o 6. Can you apply the scientific method to prediction?
o 7. Do you need a ruler in this laboratory experience?

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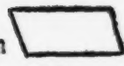
*Test prepared by Mr. LaMoine Motz, Hillside Junior High School, Kalamazoo, Michigan and graduate student in science education, Western Michigan University, and University of Michigan.

+ 8. Could a triangle or a parallelgram  be constructed so that each dot is equidistant from two of the others?
o 9. What good is the laboratory experience with the dots?
o 10. Is there any limit on how big or how little the figures could be, and still work?
+ 11. Is expectation the same as extrapolation?
+ 12. Is it interpolation to try to figure out a part of a story that you missed?
+ 13. How are predictions supported?
o 14. Why do the seasons always come in the same order?
o 15. Do all of the sides of the geometric figures have to be equal?
o 16. Why are the figures that we end up with called geometric figures?
+ 17. How does a hypothesis differ from a natural law?
+ 18. Couldn't an extrapolation be the same as a hypothesis?
+ 19. If your extrapolation is not proved to be true, do you have to change it as you would a hypothesis?
o 20. How can you make a circle out of four dots?
o 21. What is gravitation?
o 22. How can dots be considered data?
+ 23. Is a hypothesis a kind of prediction?
+ 24. If you expect to have a good time when you are invited to a friend's house, is this a kind of extrapolation?
+ 25. If you are listening to someone talking on the telephone, and try to figure out what the person to whom they are talking is saying, is this related to interpolation?
+ 26. When alternative hypotheses are set up, are both inductive and deductive processes used?
+ 27. Why can you only make seven figures out of the four bits of data?
o 28. Why do we need four dots to outline the original figure?
o 29. How many dots are needed to complete each figure?
+ 30. Why are alternative hypotheses necessary in this laboratory experience?
o 31. Why do we use a certain number of dots to start this laboratory experience?
+ 32. Why are a minimum number of dots necessary to define a figure clearly?
+ 33. How are predictions and extrapolation related?
+ 34. Why are new data necessary to solve the problem?
o 35. Is this laboratory experience based on a series of lucky guesses?
o 36. Why do people extrapolate?
o 37. In the original figure, why did each dot have to be equidistant from two others?
+ 38. If you used more than four dots to start with, how many hypotheses would you get, more or fewer?
+ 39. Do all natural laws involve extrapolation?
+ 40. Of what use is it to have additional data if it merely confirms what you already have?

Test to Determine Your Understanding of the Idea of Directional Change (Evolution)

Idea:

The idea involved in an understanding of evolution can be stated rather simply: Variation, plus the survival of that which "works," results in evolution. Evolution is the continuous adjustment of anything to the demands of a changed or changing environment.

Evolution results from a combination of two of the basic behaviors which scientists have found to be general properties of nature. (1) They have learned to expect nature to show variation and change. (2) They have also learned that in nature that which "works" survives and tends to reproduce itself.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of twenty questions.

6. Then go back again and mark "o" in front of the twenty questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

o 1. Is variation the result of natural selection?
+ 2. Is selection the only force acting on variation to produce evolutionary change?
o 3. Does a person have any of the characteristics of his ancestors, say six generations back?
+ 4. Is there any prospect of science being able to help the evolution of man in the future, by controlling his environment?
o 5. Is it possible for us to think that 200 years from now, the toes and fingers of human beings will be changed, due to the development of scientific technology?
+ 6. Considering the wide variation in present-day mankind, could another race of man develop through natural selection from existing human types?

o 7. What kinds of variations are found in present-day human races?
+ 8. What effect has environment had on the evolution of man in various parts of the world?
o 9. If all woodpeckers were placed in an environment without trees, would they start feeding on seeds picked up off of the ground?
+ 10. Could the extinction of the dinosaurs have been due to their being unable to change to adjust to the environment?
+ 11. By looking at the past and the present variety of man, is it possible to predict what natural selection will make out of man in the future?
+ 12. If a variation improves the ability of an organism to survive, will natural selection preserve this new trait?
o 13. Can a variation be successful if it is not hereditary?
+ 14. Does the climate of a region select those variations which are best adapted for survival?
o 15. Why is man believed to be developed from prehistoric animals?
+ 16. Could the intelligence of animals be controlled by selection?
o 17. Why are only some animals domesticated?
o 18. Why hasn't man's physical appearance changed as much as that of the horse?
+ 19. How do animals adapt to changes in the environment?
+ 20. If man establishes a colony on Mars, and lives there for 100 generations, will his descendants still be able to marry with humans back on earth?
+ 21. Don't climate and environment have a lot to do with what kinds of animals and plants survive?
o 22. Will our generation witness evolution in the development of the physical characteristics of man?
+ 23. How did environment affect the development of the races of man?
o 24. Does evolution take place in microscopic organisms?
+ 25. Is man shaping his present environment to fit himself or is he shaping himself to fit his environment?
o 26. If man has not yet completed his evolutionary cycle, will future changes be good or bad?
+ 27. Is survival of the fittest still taking place in man now that science and medicine have found ways of getting around man's deficiencies?
o 28. Is man really a descendant of an ape?
+ 29. How does climate affect variations in a species?
+ 30. Can a large variation in an animal cause another animal to destroy it just because it is different?
+ 31. What forces led to the selection of those variations that caused an animal to evolve into man?
o 32. How much effect do man's actions have on changing the world around him?
+ 33. Are evolutionary changes still taking place in man?
o 34. Is the rate of evolution more rapid in tropical countries?
o 35. In what way did the different races of man get started?
o 36. Is it true that hair is becoming unnecessary to man, and will ultimately disappear?
o 37. What changes have taken place in man's bone structure during his evolutionary development?
o 38. Did the different races of man evolve separately or did they all arise from the same ancestors?
o 39. Is it possible for a new form of man to arise in the future?
+ 40. Does all life evolve or simply die out when it cannot adjust to the environment?

Test to Determine Your Understanding of the Idea of Dynamic Equilibrium*

Idea:

Equilibrium means a balance, in which forces are always operating equally against one another, so that no change takes place. Examples of balance are generally the result of a series of adjustments, of "coming to balance." Most do not remain balanced for very long. None are permanent, not even those that appear to remain unchanged for long periods. Nothing really stands still. The state of balance is continually being disturbed. There is a constant state of coming to balance. This is what is meant by dynamic equilibrium.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.

2. Then read through the entire list of questions carefully without marking any of them.

3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.

4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.

5. Do this again and again until you have marked "+" in front of a total of twenty questions.

6. Then go back again and mark "o" in front of the twenty questions that are left.

7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

\+ 1. How can some people eat a lot and never gain a pound?
\+ 2. Why do you have to have a cover on your balanced aquarium?
o 3. What would happen to the earth if it lost rainfall, wind, and water?
\+ 4. If rabbits have big litters of young, why isn't the world over populated with rabbits?
o 5. Is the earth going to wear down to nothing?
o 6. Is a clock an example of dynamic equilibrium?
\+ 7. Are more people dying than there are babies being born?
o 8. What color does litmus paper turn in an acid?
\+ 9. Is a living organism an example of dynamic equilibrium?
o 10. How do waterfalls form?
\+ 11. Why do some people lose weight when they are ill, but gain weight during holidays?

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*This test includes items from tests prepared by Ted Wernert, Arthur Connerton and Carol Denesha of the Middle Schools of West Irondequoit Central School District, Rochester, New York, and Dorothy Woodside of Finneytown High School, Cincinnati, Ohio.

o 12. What are the four necessities for life?
+ 13. Is the germination, growth, reproduction and death of plant life an example of dynamic equilibrium?
+ 14. Why did the animals in polluted water die while those in the balanced aquarium live?
o 15. How will space look fifty years from now?
o 16. How do scientists use theories?
+ 17. How could a strong acid balance a weak base?
o 18. Why does a river meander?
o 19. Are white blood cells an example of dynamic equilibrium?
+ 20. If red cabbage solution did not change color when an unknown liquid was added to it, what would that tell us about the unknown liquid?
o 21. What does coloring have to do with equilibrium?
+ 22. Why did it take more ammonia than vinegar to change the color of the red cabbage solution?
+ 23. How do lakes stay filled with water?
o 24. What sea animals build up mountains?
+ 25. Is the carbon dioxide-oxygen relationship in a balanced aquarium a dynamic equilibrium?
o 26. What happens when a glacier melts?
o 27. What happens when we have a leap year?
+ 28. How long can a person stay at exactly the same weight?
o 29. Do land masses change more than oceans?
+ 30. How come some substances can be chemical indicators and others cannot be?
+ 31. Why is a balanced aquarium a better example of dynamic equilibrium than a terrarium?
o 32. How far from the sun are we?
o 33. Why and how do sand dunes move?
+ 34. Does the human population problem have anything to do with dynamic equilibrium?
o 35. What is meant by weathering?
+ 36. Does the making of canyons by flowing water have a relationship to dynamic equilibrium?
o 37. What is the green scum on the side of the aquarium?
o 38. Are there any animals that help tear down mountains?
+ 39. How can the"building up" and "tearing down" processes work opposite one another in living things?
+ 40. Will the change of colors be the same if you use a different kind of acid and base?

Test to Determine Your Understanding of the Idea of Measurement as an Expression of Relationship*

Idea:

Measurement always consists of a statement of the relationship of one thing to another in terms of quantity. We measure weight in relation to the downward pull of gravity, time in relation to cycles like day and night, and things like body height or weight in relation to the average (or norm) of a group.

We express the weight, length, thickness, and volume of objects by comparing them with arbitrary units of measurement which we have created. These units have no real meaning except as we give them meaning in terms of relationships. Also the importance of particular measurements changes in relation to the things being measured, and the use that is to be made of the measurements.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.
2. Then read through the entire list of questions carefully without marking any of them.
3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.
4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.
5. Do this again and again until you have marked "+" in front of a total of twenty questions.
6. Then go back again and mark "o" in front of the twenty questions that are left.
7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

\+ 1. Is there any way of measuring things in all different physical states?
\+ 2. Could you devise a system of measuring weight with something other than BB's and pennies?
\+ 3. Are you in a sense measuring the effect of gravity when you do a weight experiment?
o 4. How much do fifty pennies weigh?
\+ 5. What kind of units are used to measure weather?

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*Test prepared by Mr. Richard Zubulake, Hillside Junior High School, Kalamazoo, Michigan, and graduate student in science education, Western Michigan University and University of Michigan.

o 6. Were the measurements that the ancient Greeks and Romans used very accurate?
o 7. Which king said that three barley grains equaled one inch?
+ 8. When we compare two things, are we really in a way measuring them?
+ 9. When you say that an automobile is going sixty miles per hour, what are you measuring its speed in relation to?
o 10. What are the advantages of the metric system?
o 11. How does the metric system work?
o 12. Are there any scales in the world that weigh feathers?
+ 13. Is balance related to measurement?
o 14. Why do we use a scale?
o 15. How much does a penny weigh?
+ 16. Does measurement ever express the quality of something by comparing it with something else?
+ 17. When you put a penny in one can and balance it by putting BB's in the other can, is it similar to the way people used to buy groceries by taking a set weight and balancing it with the kind of food they wanted?
o 18. Why do you have to get the yard stick to balance?
o 19. Could you invent a measuring system easier for all countries to use than the metric system?
+ 20. When you measure something with a ruler, are you comparing it to the ruler itself?
o 21. What did cave men use for measuring?
+ 22. Why would a clock that measures time by atomic vibrations be more accurate than the clocks we have now?
+ 23. Can we measure anything without units of measurement?
+ 24. What relationship are we using when we measure time by a sundial?
o 25. Why has the United States been thinking of changing to the metric system?
o 26. Why do we speak of the weight of the air?
o 27. Does the modern factory use a lot of measurement in a day?
o 28. Who invented the metric system?
+ 29. How are units of measurement related to whatever it is that you are measuring?
+ 30. How could you measure space?
o 31. How do you go about learning the metric system?
o 32. Does the metric system always deal with multiples of ten?
+ 33. What kind of measurement do they use to measure the distance from the earth to the sun?
+ 34. If long ago people considered an acre to be one morning's plowing, how would they know it was accurate because people work at different speeds?
+ 35. How would you go about making a system of measurement if there were none?
o 36. Will the United States eventually change to the metric system?
+ 37. Did anyone ever use a stick for measurement?
o 38. Why is the metric system easier than the English system?
o 39. Is the metric system the simplest way to measure anything?
+ 40. If we had only millimeters, how much measuring would be done of big objects?

Test to Determine Your Understanding of the Idea of Tools as Extensions of Man's Body*

Idea:

Tools serve as extensions of man's body and its capabilities. A tool is anything which is used to solve a problem. It is something which enables man to adjust to or overcome his environment. This includes the outside sources of energy which man uses to operate his machines.

Instructions:

1. Read the Idea through carefully. You may read it again as many times as you wish to while you are taking the test.
2. Then read through the entire list of questions carefully without marking any of them.
3. Then go back and mark "+" in front of the five questions that you think are most clearly related to the Idea.
4. Now go back and mark "+" in front of the five questions that you think are next most clearly related.
5. Do this again and again until you have marked "+" in front of a total of twenty questions.
6. Then go back again and mark "o" in front of the fifteen questions that are left.
7. Think through and study each question carefully in relation to the Idea before you mark it either "+" or "o."

o 1. Could you move the earth if you had a large enough lever and something to rest it on?
+ 2. Could a piece of paper ever be considered an extension of man's body?
o 3. What is friction?
o 4. What are some simple tools?
+ 5. What does mechanical advantage mean?
o 6. Do you need air to make friction?
o 7. What are the three parts of a lever?
+ 8. Is using a piece of chalk to write with extending man's body?
o 9. What other animals use tools?
o 10. Would a 150 gram weight balance a 300 gram weight at twice the distance?
+ 11. Does a book extend man's body?
+ 12. Are computers tools?
o 13. Are there more complex machines today than 20 years ago?
o 14. Could you make a simple machine that would not cause any friction?
+ 15. Is a clock a tool?

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*Test prepared by Mr. Richard Zubulake, Hillside Junior High School, Kalamazoo, Michigan, and graduate student in science education, Western Michigan University and University of Michigan.

o 16. Does friction operate with wind and water?
+ 17. Is the use of gasoline an extension of man's body?
+ 18. Can tools be used for measuring and weighing?
o 19. Why is a lever called a machine?
+ 20. Is driving a car extending man's body?
+ 21. Can man use tools to change his environment?
+ 22. When you see how far away you can hear a watch tick, then listen to it through a paper funnel and hear it twice as far away, is this extending your body?
o 23. Could you hear through the can-and-string telephone if the string were placed underground?
+ 24. Does your mind use tools?
+ 25. Is almost everything man uses a tool?
+ 26. Can electricity be an extension of man's body?
o 27. How can a lighter weight balance a heavier one?
+ 28. Are glasses an extension of man's body to make him see better?
o 29. Did cave men use tools in ancient times?
+ 30. Would a grocery bag be an extension of man's body?
o 31. Does friction occur in most simple machines?
+ 32. Do animals such as horses and dogs sometimes act as extensions of man's body?
o 33. When did man invent the wheel?
o 34. Why can animals do some things that man can't do?
o 35. What do the terms fulcrum, effort and resistance mean?
+ 36. In the olden days, milking was done by hand. Are the machines now used for milking extensions of man's body?
+ 37. In a sense am I stronger when I use a lever to lift something?
o 38. How does man control his body?
o 39. What are the three kinds of levers?
+ 40. Is television an extension of man's body?

Test to Determine Your Understanding of Three Ideas*

Instructions:

The following three groups of twenty questions each, were taken from the list of questions that the members of the class were asked to prepare. You are asked to judge which ones apply to each basic concept as it is stated.

First: Read each idea over very carefully.

Second: Mark "+" in front of those questions which apply to the idea. It would be good to go through each list, and mark only those few which you think most clearly apply. Then go back through the questions again and mark any that you missed before. In this way, the first and best ones that you mark will serve as a standard against which you can judge the others.

Third: When you are sure that you have marked all of the "+"s, go back through each list one more time and mark "o" in front of those questions which do not apply to the idea.

Idea of Gradients:

There are no sharp boundary lines in nature. All gradients show continuous change in one direction. There are gradients of increase and gradients of decrease.

(This portion of the test was based on laboratory experiences on "Paper and Thin Layer Chromatography," and "Yeast Activity.")

\+ 1. Would a gradient result in a bucket of water under a dripping faucet?
o 2. What is the most common gradient?
o 3. How do you find a gradient?
\+ 4. Is it a gradual change when a twig is being burned?
o 5. Is it interesting to study deep into a gradient?
o 6. What does a gradient do?
\+ 7. Is there a gradient in your weight as you grow?
\+ 8. Would there be a gradient form from the evaporation of water in a bucket of water in heat all day?
o 9. What is an example of a gradient?
o 10. In what cases would a gradient be wrong?
o 11. How are gradients made?
\+ 12. How far can a gradient rise?
\+ 13. Can the gradient be measured by pounds, carrots, ounces, or anything else besides centimeters and millimeters?
\+ 14. Can the environment change a gradient?
o 15. Who invented the gradient?

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*Test prepared in connection with doctoral dissertation at University of Georgia by Dr. Phyllis E. Carnes, National Institutes of Health, Washington, D.C.

o 16. Can gradients help you in science?
o 17. Why is a gradient important?
+ 18. I wonder if you could predict how high a color would rise on filter paper.
+ 19. How long would a gradient keep on going?
+ 20. If we had the amounts of blood cells in different peoples' blood, would it form a gradient?

Idea of Normal Curves and Sampling:

As the scientist works, he discovers certain patterns in nature which frequently take the form of normal curves or "bell curves." Sometimes these are modified curves which are the result of warping factors.

(This portion of the test was based on laboratory experiences on "Use of Normal Curves in Distinguishing Species" and "Normal Curves Describe Variation in Nature")

+ 21. Do you only get normal curves with plants or could you measure the length of a group of children's pencils at the end of a week?
+ 22. When you graph any human characteristic is it possible to have a perfect normal curve?
+ 23. Isn't a graph the best way to see if you have a bell-shaped curve?
o 24. What language is usually used in classifying plants?
+ 25. Are there any populations exactly alike?
+ 26. When you have a warping factor, is there a mode?
o 27. Why is measuring leaves important?
o 28. What does an overlap look like?
+ 29. Is it possible to measure a hundred of something and not have any sign of a normal curve?
o 30. Do all leaves have a certain pattern?
o 31. In a class with students' heights between four feet and six feet, who would you pick as a sample?
+ 32. If you measured 1000 lima beans would you have a better curve than with 100?
o 33. What type of graph do you use most?
+ 34. Why do different graphs of the same species have different norms?
o 35. Where do most graphs make their peak?
+ 36. Was the only purpose in measuring these things to see how it formed a bell-shaped curve?
o 37. Does Chinese elm belong to the same genus as the American elm?
+ 38. Can warping factors be good and helpful as well as bad and harmful?
+ 39. If you measured the height of one hundred people would you get a normal curve?
o 40. Who started science?

Idea of Measurement as an Expression of Relationship:

Since earliest times, measurement has always consisted of an expression of the relationship of one quantity to another. Continued use of certain relationships has led to standardization, and as a result certain basic systems of measurement are now in use.

(This portion of the test was based on the laboratory experience "A Simple Balance.")

+ 41. Is weighing done with quarter-inches and BBs very accurate?
o 42. What does standard measurement have to do with units of measurement?
+ 43. Are old sayings an accurate way to measure or compare things?
o 44. Why should each kind of part in a scale be uniform?
+ 45. Is a bucket-full a very accurate measurement?
o 46. What do you think is the best measurement?
o 47. What is the best measurement for measuring long distances?
o 48. Why is a correction factor necessary?
+ 49. How can a measurement express a thought?
+ 50. If there were only meters how much measuring would be done on small objects?
o 51. Why did we have to move the cans up every time we added BBs?
+ 52. Could we have used rocks in weighing instead of BBs?
+ 53. Can we measure the length of leaves to get a quantity?
+ 54. Can we compare measurement with a standard?
o 55. What is the reason that we use the multiples of ten in measurements?
o 56. Why should you put the main string through the 18-inch mark and not the 16 or 17-inch mark?
+ 57. Why do you think when you are measuring BBs in cans that when you have the same number of BBs in each can, they do not balance?
+ 58. Is spreading your hands out with your thumbs touching each other a good way to measure a foot?
+ 59. What does standard measurement have to do with a ruler?
o 60. How did the metric system originate?